Announcements

1. Answers to first hour test posted:
   http://www.wfu.edu/~natalie/f02phy113/extrapractice/

2. Topics for today –

   conservation of momentum

   conservation of energy

   center of mass

Linear momentum: $\mathbf{p} = m\mathbf{v}$

$$\mathbf{F} = \frac{d\mathbf{p}}{dt}$$

Generalization for a composite system:

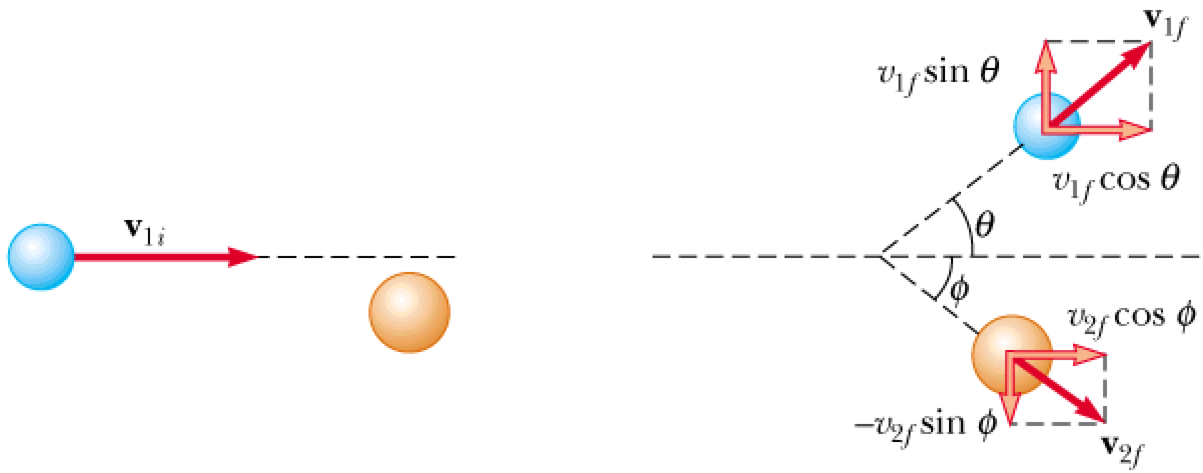
$$\sum_i \mathbf{F}_i = \sum_i \frac{d\mathbf{p}_i}{dt}$$

Conversation of momentum:

If $\quad \sum_i \mathbf{F}_i = 0; \Rightarrow \sum_i \frac{d\mathbf{p}_i}{dt} = 0; \Rightarrow \sum_i \mathbf{p}_i = (\text{constant})$

Energy may also be conserved (for example, in an "elastic" collision)

Serway, Physics for Scientists and Engineers, 5/e
Figure 9.14



(a) Before the collision (b) After the collision

Statement of conservation of momentum:

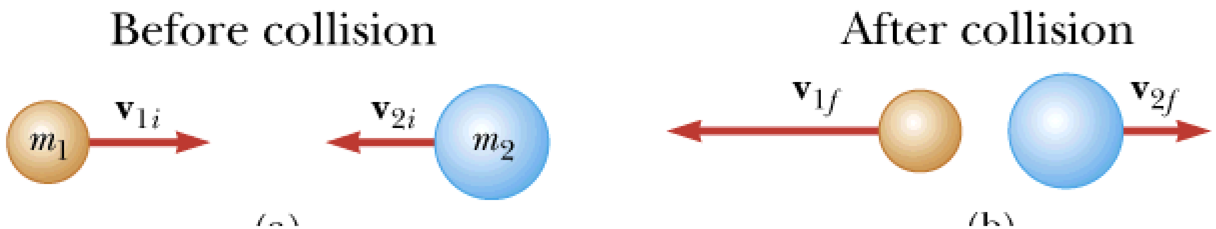
$$m_1 v_{1i} = m_1 v_{1f} \cos\theta + m_2 v_{2f} \cos\varphi$$

$$0 = m_1 v_{1f} \sin\theta - m_2 v_{2f} \sin\varphi$$

If mechanical (kinetic) energy is conserved, then:

$$\tfrac{1}{2} m_1 v_{1i}^2 = \tfrac{1}{2} m_1 v_{1f}^2 + \tfrac{1}{2} m_2 v_{2f}^2$$

Figure 9.10



One dimensional case:

Conservation of momentum: $m_1v_{1i} + m_2v_{2i} = m_1v_{1f}+m_2v_{2f}$

Conservation of energy:

$$\tfrac{1}{2}\, m_1v_{1i}^2 + \tfrac{1}{2}\, m_2v_{2i}^2 = \tfrac{1}{2}\, m_1v_{1f}^2+ \tfrac{1}{2}\, m_2v_{2f}^2$$

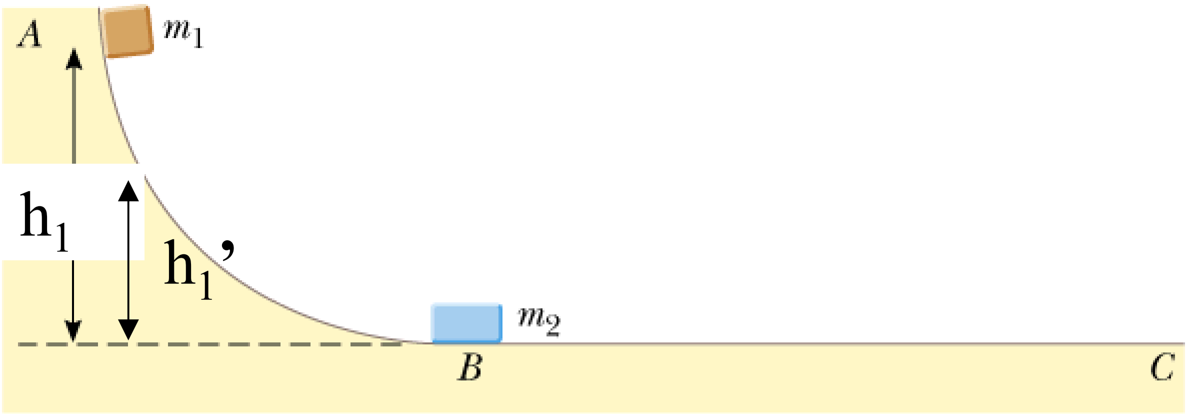
Extra credit: Show that

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_{1i} + \left(\frac{2m_2}{m_1 + m_2}\right)v_{2i}$$

$$v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right)v_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2}\right)v_{2i}$$

Serway, Physics for Scientists and Engineers, 5/e
Problem 9.26

Homework problem



1. m_1 falls a distance h_1 – energy conserved
2. m_1 collides with m_2 – momentum and energy conserved
3. m_1 moves back up the incline to a height h_1'

Extra credit:

Show that $$h_1' = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)^2 h_1$$

On line quiz question:

Suppose a nucleus which has an initial mass of M_i= 238 m_0 (where m_0 denotes a standard mass unit),suddenly decomposes into two smaller nuclei with M_1 = 234 m_0 and M_2 = 4 m_0.

If the velocity of nucleus #1 is V_1 what is the velocity of nucleus #2?

(a) -0.017V_1 (b) -0.131V_1 (c) -0.983V_1 (d) -7.6V_1 (e) -58.5V_1

After the decomposition which nucleus has more energy?

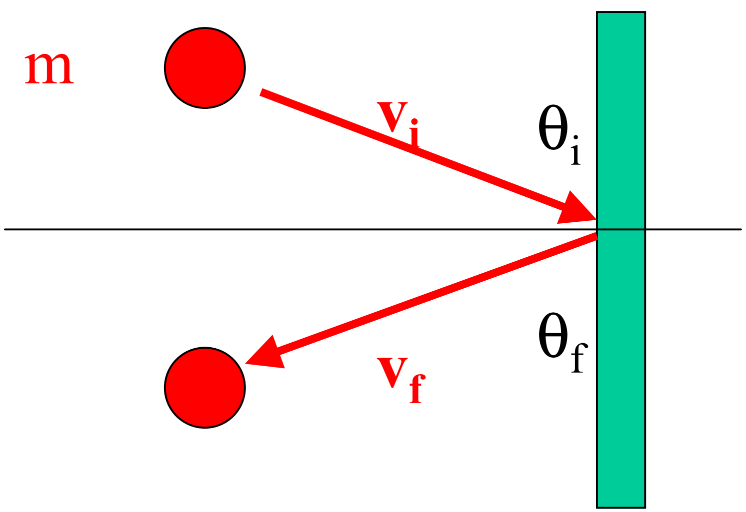
(a) M_1 (b) M_2 (c) The nuclei have the same energy.

(d) Not enough information is given.

Notion of impulse:

$$\mathbf{F} = \frac{d\mathbf{p}}{dt} \quad \Rightarrow \mathbf{F}\Delta t = \Delta\mathbf{p}$$

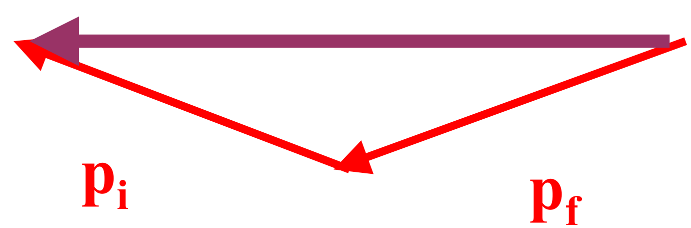
Example:



$$\Delta\mathbf{p} = m\mathbf{v_f} - m\mathbf{v_i}$$

$$\Delta\mathbf{p} = (mv_f \sin\theta_f + mv_f \sin\theta_f)\ \mathbf{i}$$

$$+(-mv_f \cos\theta_f + mv_f \cos\theta_f)\ \mathbf{j}$$



Composite systems:

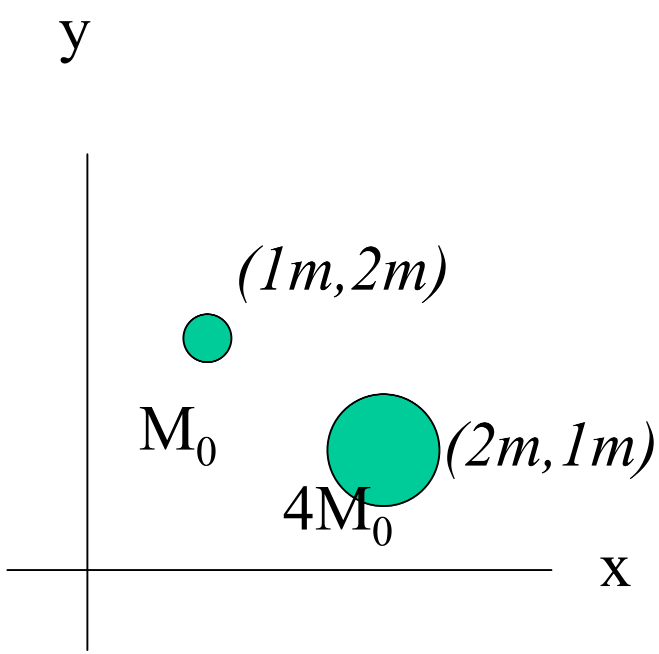
$$\sum_i \mathbf{F}_i = \sum_i \frac{d\mathbf{p}_i}{dt} = \sum_i \frac{dm_i\mathbf{v}_i}{dt}$$

Define center-of-mass velocity: $\mathbf{v}_{\mathrm{CM}} \equiv \dfrac{\sum_i m_i \mathbf{v}_i}{\sum_i m_i} \equiv \dfrac{\sum_i m_i \mathbf{v}_i}{M}$

Note that: $\sum_i \mathbf{F}_i \equiv \mathbf{F}_{total} = M\,\dfrac{d\mathbf{v}_{\mathrm{CM}}}{dt}$

Define center-of-mass displacement: $\mathbf{r}_{\mathrm{CM}} \equiv \dfrac{\sum_i m_i \mathbf{r}_i}{\sum_i m_i}$

Example of center of mass:



$\mathbf{r}_{CM}$=(1/5* 1+4/5*2)m $\mathbf{i}$ + (1/5* 2+4/5*1)m $\mathbf{j}$

= 1.8 m $\mathbf{i}$ + 1.2 m $\mathbf{j}$

Peer instruction question:

Romeo (60 kg) entertains Juliet (40 kg) by playing his guitar from the rear of their boat (100 kg) which is at rest in still water. Romeo is 2m away from Juliet who is in the front of the boat. After the serenade, Juliet carefully moves to the rear of the boat (away from shore) to plant a kiss on Romeo's cheek. How does the boat move relative to the shore in this process? (Initially Juliet is closest to the shore.)

(a) 0.2 m away from shore (b) 0.4 m away from shore

(c) 0.2 m toward shore (d) 0.4 m toward shore